UCRL-JC-124866 Abs

Maximum background pressure in spatial filters for high power lasers

J. E. Murray, D. Milam, W. D. Sell, K. G. Estabrook, M. D. Feit, A. M. Rubenchik

University of California
Lawrence Livermore National Laboratory
P.O. Box 808, L-473
Livermore, CA 94550
(510) 422-5481 / FAX (510) 423-9242

Abstract submitted to
2nd Annual International Conference on Solid-State Lasers for Application to Inertial Confinement Fusion (ICF)
PARIS, France (1996)

The maximum operating pressure for spatial filters is important to the National Ignition Facility (NIF) Project. At too high a pressure ionized gas near the focus will distort and/or absorb a transmitted pulse, causing problems of beam-to-beam power imbalance, peak-to-average beam modulation, and reduced harmonic generation efficiency. On the other hand, the highest acceptable pressure might reduce optics contamination from pinhole and beam-dump ablation products. Also, if the NIF spatial filters could operate with mechanical pumps only (i.e. at pressures > 10^{-3} Torr), it would save several 10's of M$. Consequently, we want to know the threshold pressure at which absorption or distortion of the transmitted pulse just begins for the NIF spatial filters. The maximum operating pressure should be about 10x lower than this threshold pressure for operational ease.

The pre-existing data on spatial filter threshold pressures presents an optimistic picture for operating NIF with only mechanical pumps. The following table shows data reported for several high-power laser systems as well as for the NIF spatial filters.

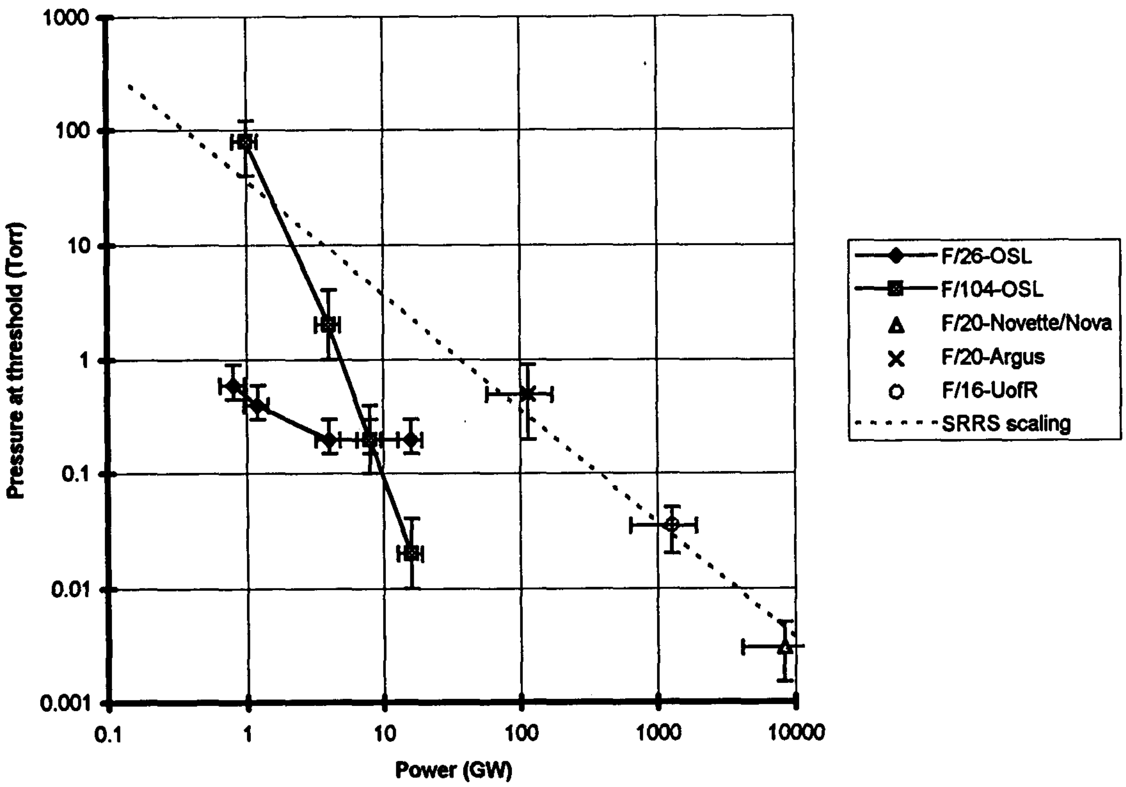
	Power (TW)	pres at threshold (Torr)	F-number
Argus (LLNL)	0.11	0.5 ± 0.3	20
Omega[1] (LLE)	1.3	.035 ± .01	14
Novette/Nova (LLNL)	8	.003 ± .001	20
NIF cavity filter	2	(?)	32
NIF transport filter	4	(?)	75

The mechanism assumed responsible for the Omega data[1] is stimulated rotational Raman scattering (SRRS), in which case the pressure-at-threshold should scale as (pressure)x(power), independent of F-number. The three sets of data in the table

* Work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract No. W-7405-ENG-48.

agree reasonably well with this scaling, giving a value of (pressure)x(power) ≈ .04 ± .02 TW-Torr. This, in turn, implies a pressure-at-threshold for the NIF spatial filters of .01 to .02 Torr, which is high enough to rely on mechanical vacuum pumps only.

We tested this scaling relationship with F/26 and F/104 spatial filters using the 1053 nm output of the Optical Sciences Laser (OSL) at LLNL. The following figure shows these results as well as those in the table. Clearly, the OSL data does not agree



with the SRRS scaling, and it shows a very strong dependence on F-number, which the SRRS mechanism would not. Furthermore, we looked for the first-Stokes SRRS lines for nitrogen above and below these threshold pressures, and we saw no shifted light. LASNEX[2] calculations which do agree with the OSL data find the dominant effect is filamentation in the plasma. We conclude that SRRS is not necessarily the mechanism causing the observed values of pressure-at-threshold, at least for the OSL data. Given these results, we have recommended a maximum operating pressure for the NIF spatial filters of < .001 Torr. More experiments are planned to increase confidence in this number.

* Work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract No. W-7405-ENG-48.

References

1) M. D. Skeldon, "Transverse modulation instabilities in the presence of stimulated rotational Raman scattering with a high-energy laser", Optics Letters **20**, 8, 4/15/95, 828 - 30.

2) G. D. Zimmerman, W. L. Kruer, Comments in Plasma Physics & Controlled Fusion **2**, p51, 1977.

* Work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract No. W-7405-ENG-48.